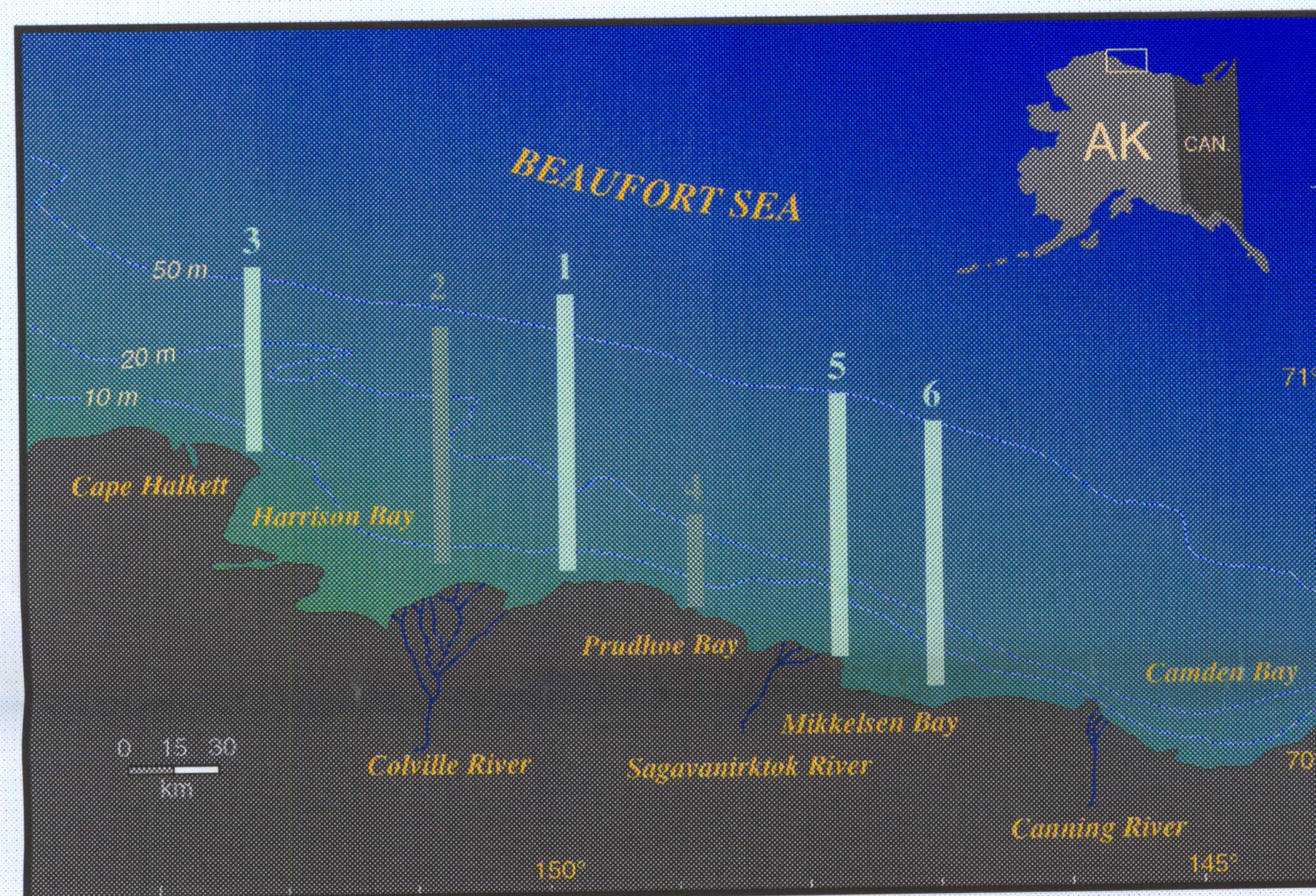


Introduction

We are engaged in a five-year study to test the hypothesis that methane from decomposing gas hydrates may contribute methane to the atmosphere. The release of methane, a "greenhouse" gas, can enhance global warming and be a factor in global climate change. As part of the study we have measured the methane concentration in the water column of the Beaufort Sea shelf out to water depths of 90 meters from 1992-1995. In 1994 the carbon isotopic composition of methane in seawater of the Beaufort Sea shelf from Cape Halkett to Mikkelsen Bay (total water depths from 3 to 56 m) was measured by gas chromatography-isotope-ratio mass spectrometry in an effort to define the source of methane. Concentrations of methane in the water samples used for isotopic analysis ranged from 5.4 to 275 nM.

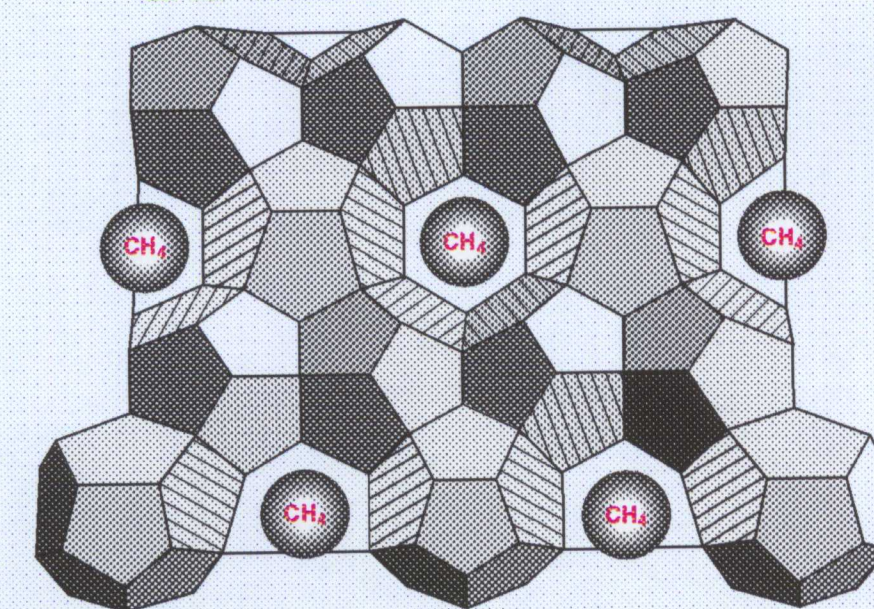
The Study Area



Six north-south transects have been established on the Beaufort Sea shelf adjacent to Prudhoe Bay, Alaska. Methane from transects 2 and 4 has not been analyzed for carbon isotopic composition.

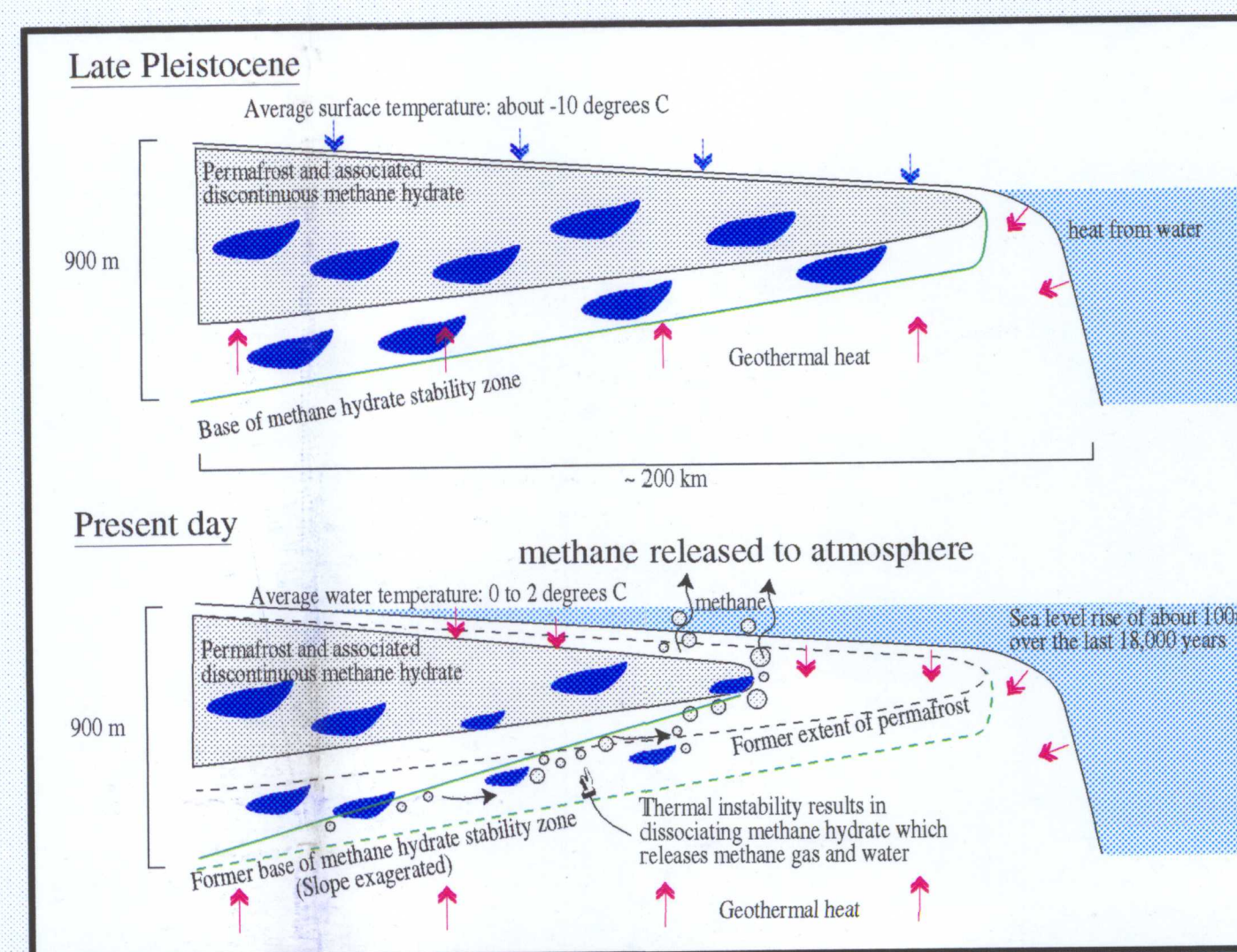
Gas Hydrate: a closer look

GAS HYDRATE STRUCTURE I



Gas hydrate is a naturally occurring solid composed of water molecules forming a rigid lattice of cages (clathrate) with most of the cages each containing a molecule of methane. When the all cages are occupied by methane, one unit volume of gas hydrate contains about 170 volumes of methane gas at STP. Thus, gas hydrates can be a significant source of methane.

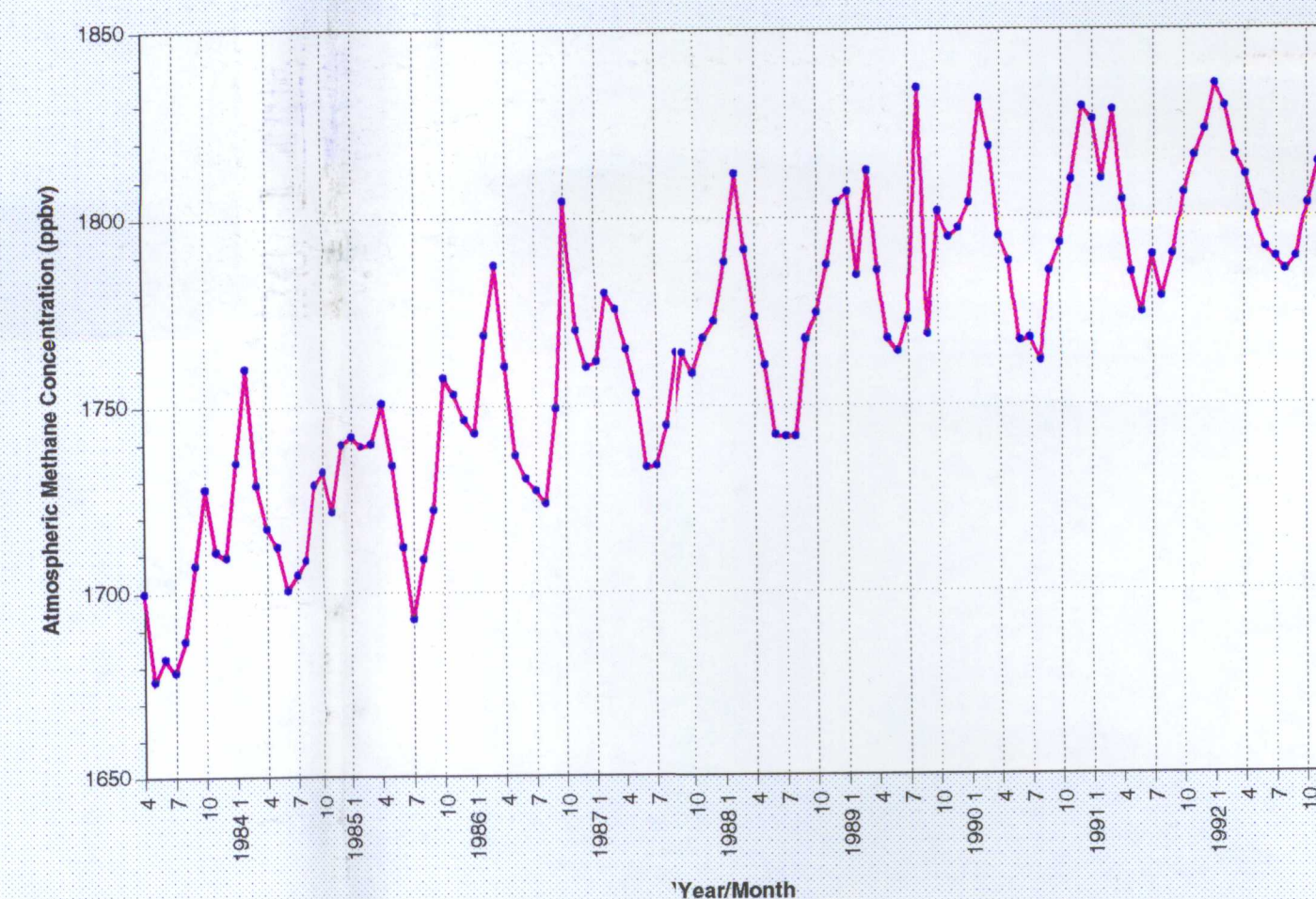
The Model



Gas hydrates associated with offshore permafrost are expected to be present because of their nearby occurrence on land. The continental shelf gas hydrates in this area and elsewhere on the Arctic shelf should currently be undergoing dissociation. In this model, the transgression of the Arctic Ocean over the previously exposed continental shelf during at least the last 10,000 years has brought a temperature change to the surface sediment of about +10°C. In addition, heat associated with the Earth's geothermal gradient creeps upward into the gas hydrate stability field from below. Thus there has been sufficient time and warming to cause part of the gas hydrate reservoir to become unstable and release methane, mainly at the seaward edge of the drowned permafrost. Some of this methane may migrate through the sediments and escape from the seafloor as natural gas seeps then into the water column where it can be measured.

Atmospheric Observations

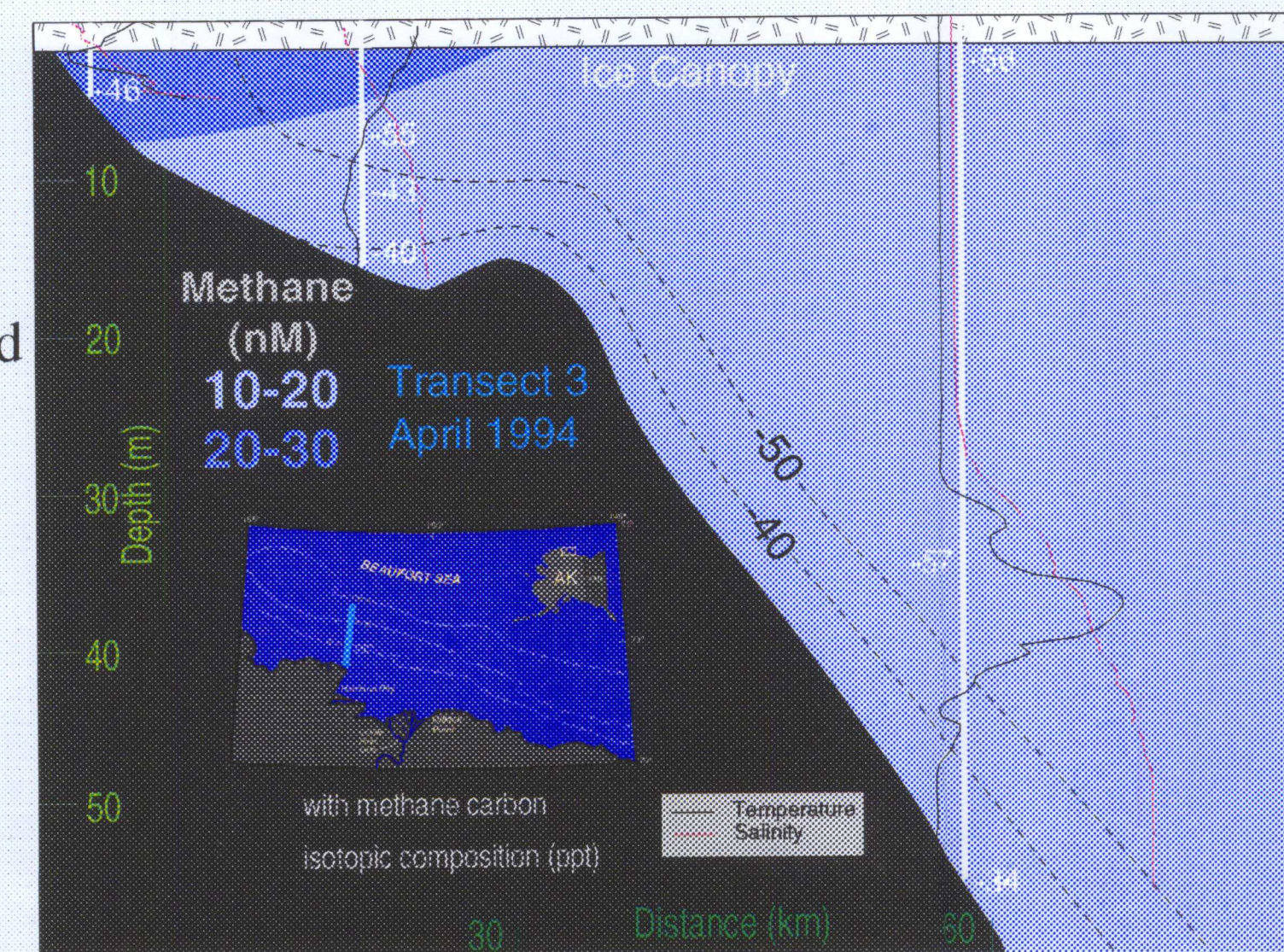
Mean Monthly Concentration of Atmospheric Methane at Barrow, Alaska
1983-1993



Mean monthly measurements of atmospheric methane concentration made at Barrow, Alaska by NOAA/CMDL personnel. The overall trend shows an increase in the concentration of atmospheric methane. Each year methane concentrations begin to increase by the end of summer, peak in the winter months, then decline during spring. These seasonal trends are seen worldwide, but the amplitude is greatest in the Arctic. We suggest methane released from the Arctic Sea shelfal waters when the ice recedes is, in part, responsible for the sharp increase in methane seen from about July through October each year.

West to East

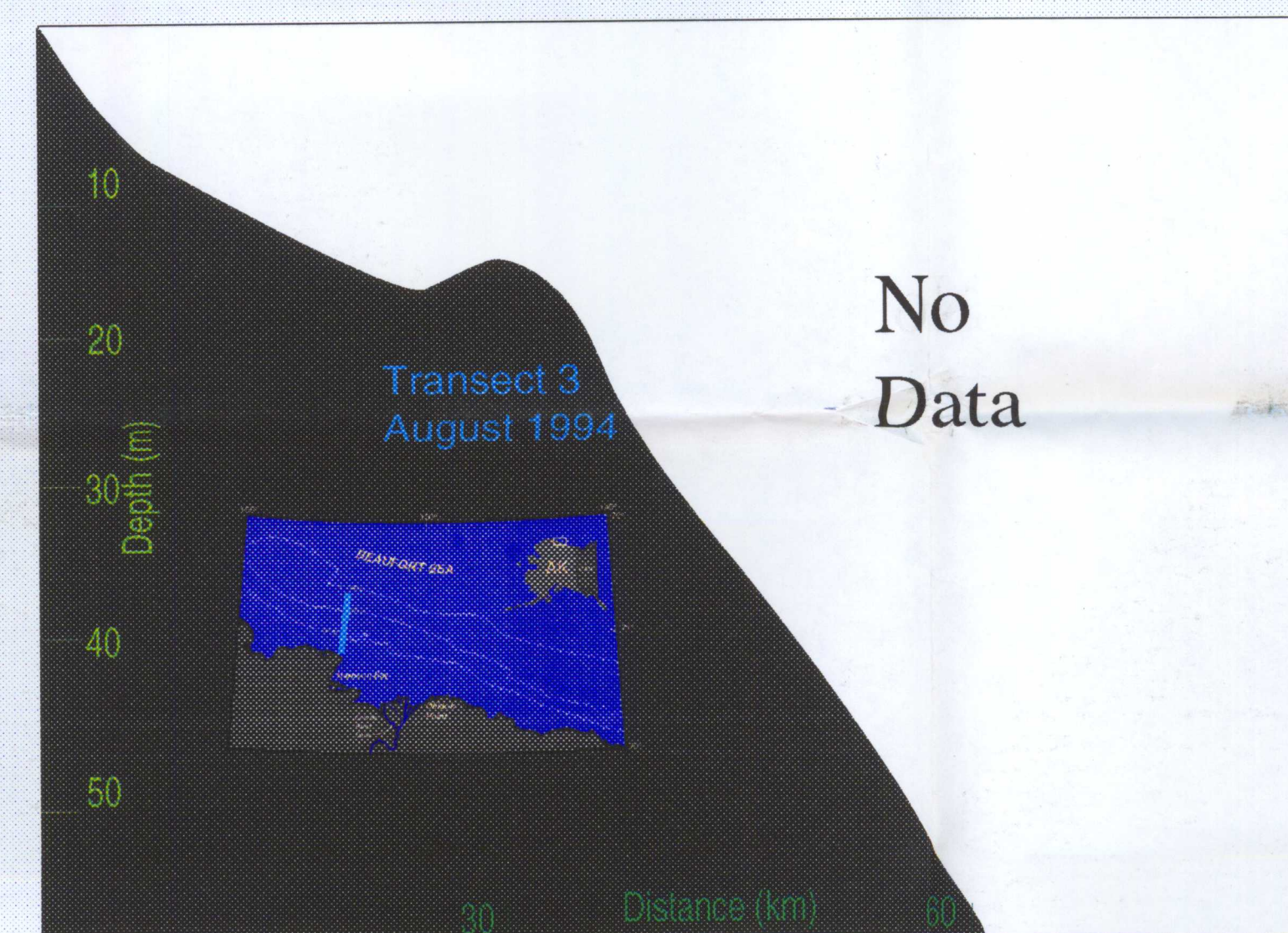
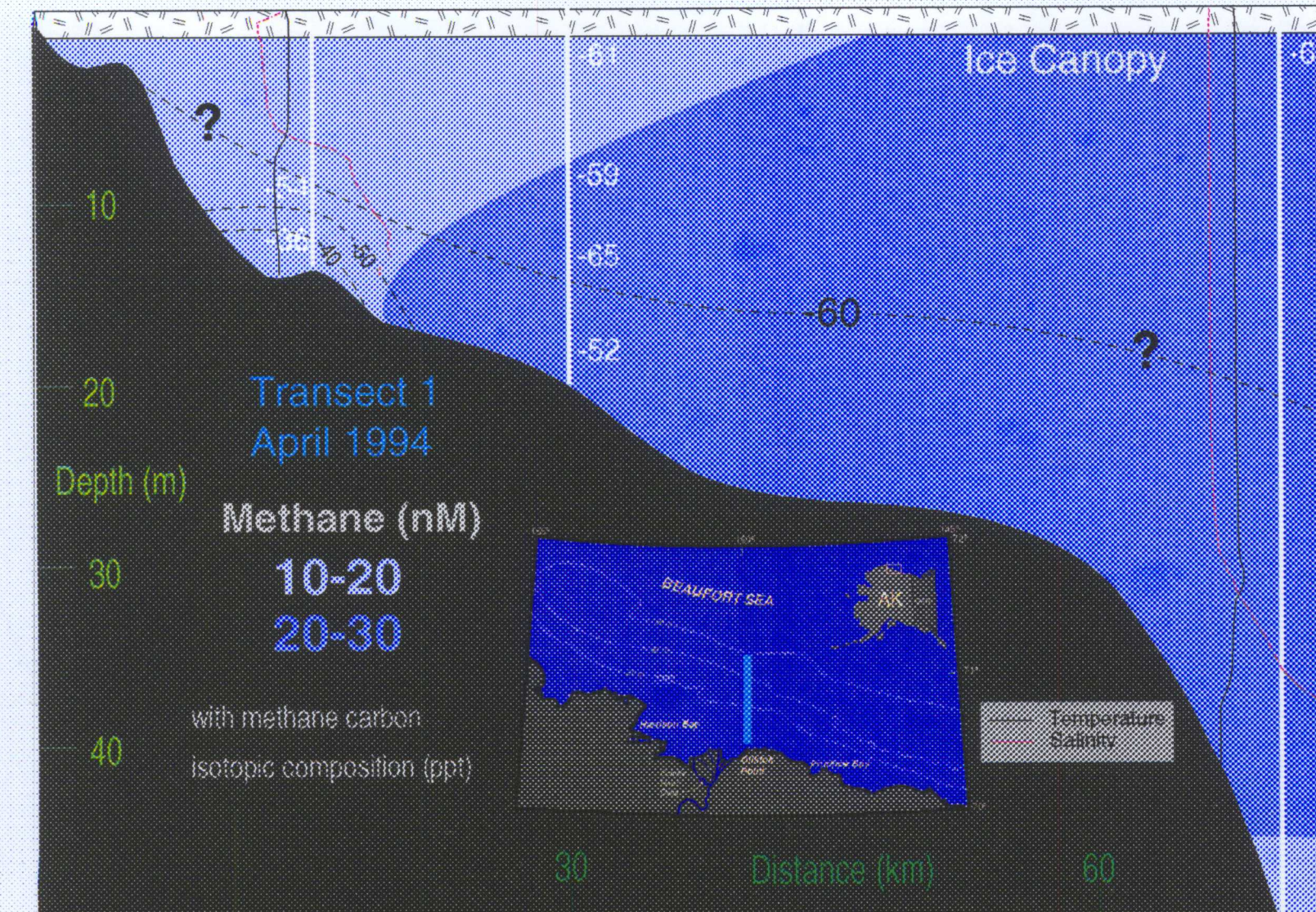
Transect 3



Ice-Covered
Water

April
1994

Transect 1



Ice-Free
Water

August
1994

No
Data

Results

The panels illustrate a cross section of each transect at two different times of year; ice-covered and ice-free waters. During ice-covered periods (October-May) the sea ice canopy traps methane in the water column. During ice-free periods (June-September) methane is released to the atmosphere. Methane concentrations are contoured by color, and overlain by the methane isotopic composition contours. Actual values are noted at the sample depths. Each station is represented by the long white lines. Also depicted are the relative values of water salinity and temperature recorded by concurrent CTD casts.

Discussion and Conclusion

Samples were collected at two distinct times: in April, when the sea is ice covered, and in August, when the sea is not covered with ice. Water with relatively low methane concentrations (5.4 to 28.4 nM), had a relatively narrow range of isotopic compositions from about -40 to -60‰; the source of methane is enigmatic. Direct comparison of water samples from the same sites taken in April and August had a pronounced seasonal shift in methane concentrations and isotopic compositions: for example, in April, 168 nM, -80.5‰, and 103 nM, -73.0‰; in August, 13.3 nM, -40.6‰, and 6.2 nM, -47.5‰, respectively. The large change in methane concentrations and isotopic compositions suggest a strong seasonal source of methane produced by microbial decomposition of organic matter during ice-covered periods. After the ice recedes, the methane may be oxidized or enter the atmosphere.

Water samples with the highest concentrations of methane in April (37.8 to 275 nM) had the lightest isotopic compositions ranging from -69.2 to -80.5‰, indicating a microbial source, and came from waters where the depth never exceeded 5 m. The highest concentrations of methane observed in August (34.9 to 148.6 nM) had the heaviest isotopic compositions ranging from -36.0 to -46.4‰, suggesting a thermal component in the methane source. One sample collected due north of Oliktok Point, Transect 1, 2 m above the bottom at a depth of 18 m, is of interest because the high concentration of methane (148.6 nM) with a carbon isotopic composition of -46.4‰, a value suggesting methane from dissociating gas hydrate (average isotopic composition of methane from gas hydrates in the nearby Kuparuk River Oilfield is -46.3‰). A concentrated bottom source of methane (94.4 nM at 21 m) was previously found very near this site in May 1992, but not at three other times in 1993 and 1994.

Thus far, the isotopic composition of the methane suggests that microbial methane is produced and pooled in nearshore regions, predominantly in water depths of 10m or less. Methane with a strong thermal signature (< -40‰) is less common and occurs mainly in the near-bottom waters along transects 1, 5, and 6. In addition the thermal signature was only observed during the August 1994 survey, with one exception along transect 1 in the April 1994 survey. Only along transect 1 between 14m and 20m water depth are gas hydrates suspected as a source of methane. Our evidence indicates that methane with an average gas hydrate isotopic composition enters the water from a confined area such as a seep.

Maps Showing Isotopic Composition of Methane in Seawater of the Alaskan Beaufort Sea, 1994

By

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